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Date: 08/07/2006

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10/589079

IAP20 Rec'd PCT/PTO 11 AUG 2006

WO 2005/078144 PCT/EP2005/000853

IP 5081
Ge/Sc

Method for Producing a Component by Reshaping a Plate, and Device for Carrying Out Said Method

DESCRIPTION

The invention relates to a method for producing a component by reshaping a coated, preferably aluminum-coated plate of quenched and tempered steel as claimed in the preamble of claim 1. The invention furthermore relates to a device for carrying out said method.

The prior art generally discloses various forming processes for sheet bars from quenched and tempered steel in conjunction with hardening processes. In a so-called "direct" forming process a flat sheet bar of quenched and tempered steel is austenitized in a furnace, preferably a continuous furnace, in a protective gas atmosphere. For example, a quenched and tempered steel of 22MnB5 grade which is annealed for several minutes at approximately 950°C for austenitizing can be used. Then the hot, austenitized flat sheet bar is inserted with a preferably automated transfer means into a forming/tempering tool which is cooled for serial processes. This tool is a component of a press and when the latter is closed, the hot sheet bar is formed into a component of the final shape and in the closed tool, when the closing force is applied, it is cooled relatively quickly and thus hardened. The hardened component is removed from the tool, and if it is uncoated sheet, it is descaled in a cleaning step, for example by sand blasting or shot peening (this is not essential for coated components, since for example aluminized sheets offer sufficient corrosion protection and scaling is prevented). This is followed by finish contour and hole trimming of the finish-formed and hardened component, preferably by means of laser cutting. Mechanical cutting in a so-called press combination is also conceivable.

During heat treatment in the furnace, for example an aluminum coating approximately 25 μm thick in the initial state undergoes growth in layer thickness to approximately 45 μm, and directly bordering the base material of the sheet bar an AlSi layer with iron diffused therein is formed therefrom, which layer bears a relatively hard and brittle AlSi layer also forming which performs the actual anticorrosion function.

A typical process sequence (hot forming curve 20) with respect to heat treatment of the sheet bar in the course of its forming is shown for example in FIG. 1 in a time-temperature diagram. Depending on the grade of the quenched and tempered steel used, sheet metal thickness, initial layer thickness, etc., the values given in FIG. 1 are of course subject to certain fluctuations (lower/upper heat treatment boundary 18, 19). Thus it is easily conceivable for the sheet bar to be in the furnace over a residence time of up to 30 minutes.

The furnace used is often a so-called continuous furnace with mold nests or sheet bar receivers, or a grate pusher-type furnace with grates which carry the sheet bars and heat them within approximately 2 minutes by means of gas burners to the austenitization temperature and then keep them at this temperature for several minutes by means of electrical heating. The advantage of the gas burner is higher output, conversely conventional electrical heating can be better controlled.

As shown in FIG. 1 the sheet bar is heated in the furnace to a target temperature of approximately 950°C and kept at this temperature. Austenitization is done at temperatures above approximately 720°C. Conventionally the residence time in the furnace is approximately 9 minutes, the sheet bars within the first two minutes heating to the target temperature, while in the following approximately 7 minutes regranulation of the base material from a cubic-space centered ferrite-perlite structure into cubic surface-centered austenite which is necessary for hardening takes place. In addition, the indicated time interval is also important mainly to achieve sufficient growth of the ALSi protective layer.

In particular, with respect to the minimum annealing temperature and maximum residence time of the sheet bar in the furnace there are certain, more or less narrow limits, within which the process delivers quality components, i.e., that the sheet bars removed from the furnace can still be used for the forming process and further applications. If a problem arises in the continuing process, whether when a sheet bar is removed from the furnace and further transported to the forming/tempering tool or within the finish contour and hole trimming station, for the duration of the problem no more sheet bars can be removed from the furnace, the maximum allowable residence time is generally exceeded, and all the sheet bars in the furnace are scrap and must be disposed of.

The object of the invention is to develop the generic process for producing a component by forming a coated sheet bar of quenched and tempered steel such that the process sequence can be optimized and that especially the costly formation of scrap sheet bars can be prevented if process disruptions arise.

This object is achieved with respect to the process with the other features according to the characterizing part of claim 1 and with respect to the device for carrying out the process as claimed in the invention with the features of claim 10.

The advantages of the procedure as claimed in the invention are manifold. Thus, now there is no longer any relationship with respect to the residence time of the sheet bars within the furnace and problems in the process outside the furnace. By decoupling the sequences for the actual process of sheet bar forming, the amount of area required and infrastructure are less. Buffering/intermediate storage of the quenched and tempered sheet bars is possible so that heat treatment, to influence the AlSi layer, additionally can easily take place at the steel manufacturer or sheet metal supplier.

This upstream heat treatment removed from storage is already known, as follows from EP 0 946 311 B1 and DE 102 12 400 C1. Annealing treatment by means of induction heating viewed in itself is also already prior art, as is also mentioned for example in the latter document.

Advantageous embodiments and developments of the invention are claimed in the dependent claims.

The invention will be detailed below using the exemplary embodiment.

FIG. 1 shows the process sequence as claimed in the invention for producing a component by forming a sheet bar,

FIG. 2 shows the temperature-time diagram of the first sheet bar heat treatment, and

FIG. 3 shows the temperature-time diagram of the second sheet bar heat treatment.

FIG. 1 schematically shows the process sequence as claimed in the invention for producing a component 5 by forming a coated sheet bar 1 of quenched and tempered steel by means of a device 2 suited for this purpose. From the steel delivered in the rolled state, a so-called coil 3, by means of a tool 4 the steel is unrolled, flattened, and the size of the sheet bar 1 necessary for the finished component 5 is punched out or cut to size. From there the sheet bars 1 are supplied to a buffer zone 6. This intermediate storage is not absolutely necessary, rather the sheet bars 1 can also be supplied directly after leaving the tool 4 to a first furnace 7 in which they undergo heat treatment according to the temperature-time diagram shown in FIG. 2. Directly downstream from the first furnace 7 is a cooling zone 8 in which the sheet bars 1 are quenched and pass through the concluding phases of heat treatment. Leaving the cooling zone 8, the quenched and tempered sheet bars 1 are supplied to an intermediate storage 9.

The first furnace 7 can be the aforementioned continuous furnace, a revolving furnace, or the like in terms of its structural design.

The individual phases of heat treatment were explained in the introductory section with reference to FIG. 2. The relatively slow heating to the target temperature and the remaining residence time in the first furnace 7 for inducing austenitization and for changing the topography (coating structure, layer thickness) add up to the total residence time of approximately 9 minutes, and empirically a maximum residence time of 30 minutes should not be exceeded, so that the sheet bar does not become unusable. The transport into the cooling zone 8 and the quenching of the sheet bar 1 there take place within relatively short time intervals, while the remaining cooling to room temperature RT can take place in the intermediate storage 9. At the end of heat treatment the sheet bar 1 has a martensitic structure.

By means of a suitable transport device 10, for example an articulated arm robot, the sheet bars 1 are supplied to an induction furnace 11, from where they are inserted into a cooled forming/tempering tool 13 suitable for serial processes by way of another transport device 12, for example in turn an articulated arm robot. A press means 14 and a cooling device 15 are assigned to the tool 13, and when the press means 14 is closed the hot sheet bar 1 is formed into a component 5 with the final shape and is rapidly cooled and hardened in the closed forming/tempering tool 13 with the closing force applied. In the last process step each component 5 is supplied via a transport means 16 to a trimming device 17, where finish contour and hole trimming of the completely formed and hardened component 5 is done preferably by means of laser cutting. Of course this can also take place mechanically by way of suitable trimming blades.

The heat treatment of the sheet bar 1 which takes place in the induction furnace 11 and in the downstream forming/tempering tool 13 is illustrated in the temperature-time diagram as shown in FIG. 3 using the hot forming curve 20 and lower/upper heat treatment boundary 18, 19. It is

characterized by an extremely short residence time of the sheet bar in the induction furnace 11. While heating to the target temperature (austenitization temperature) takes place within a few seconds (approximately ten seconds), a downstream short residence time of approximately ten seconds up to a maximum two minutes is used to allow a structure transformation to take place. A change of thickness and structure of the coating is no longer necessary since this has already taken place in the first furnace 7. After an accordingly extremely short residence time in the induction furnace 11, the sheet bar can be supplied to the forming/tempering tool 13 in which in addition to forming, quenching takes place in the same manner (same behavior of the hot forming curve 20) as in the cooling zone 8. When leaving the forming/tempering tool 13 the component 5 already has a martensitic structure, cooling to room temperature RT can take place upon further transport to or within the trimming device 17.

In this way a sheet bar 1 having an original tensile strength of approximately 500 to 600 N/mm^2 is formed into a component 5 having a tensile strength of approximately 1300 to 1500 N/mm^2.

In an advantageous development of the invention it would be conceivable to heat the sheet bar 1 in the induction furnace 11 in part to different intensities, with the result that if desired the formed and quenched component 5 has partially different strengths.

Furthermore, it would be possible preferably to locally reinforce the sheet bar 1 before the second heat treatment (induction furnace 11) for example by welding on reinforcing sheets (patches). A composite sheet patched in this way could then be sent to the second furnace and afterwards to the forming/tempering tool 13. This would have altogether positive effects on the material properties and accuracy of shape.

The process as claimed in the invention can also be advantageously used when using tailored blanks as sheet bars.

One important advantage of the invention is the possibility of decoupling the individual process steps. Thus the first heat treatment in the furnace 7 can take place at the steel or sheet manufacturer and the sheet bars 1 pretreated in this way can then be made available to the processing company (for example, motor vehicle manufacturer) (intermediate storage 9).

In another advantageous development of the invention it is conceivable to assign an inductor to the transport device 10 and to structurally integrate it into the transport device 10, so that the heat treatment of the sheet bar 1 can proceed during its transport to the forming/tempering tool 13. A separate induction furnace 11 and another transport device 12 downstream from it can thus be eliminated.